

Applicant: Williams et al.

For: Apparatus and Method for Measuring the Mass of a Substance

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1. An apparatus for measuring the mass of a substance comprising:
2. a sensor having a membrane layer, the membrane for receiving the
3. substance thereon;
4. an oscillator device for driving said membrane at a reference resonant
5. frequency;
6. a frequency detection device for determining a change in the reference
7. resonant frequency caused by the presence of the substance on the membrane; and
8. a mass determining device for determining the mass of the substance, the
9. amount of change in the reference resonant frequency being indicative of the mass of the
10. substance.

1. 2. The apparatus of claim 1 wherein said sensor is a flexural plate wave sensor.

1. 3. The apparatus of claim 2 wherein said flexural plate wave sensor is formed
2. from a silicon substrate and said membrane is formed from a silicon layer.

1. 4. The apparatus of claim 3 wherein said flexural plate wave sensor further
2. includes a piezoelectric layer formed on said membrane, a first transducer disposed on said
3. piezoelectric layer and a second transducer disposed on said piezoelectric layer, spaced
4. from said first transducer.

1 5. The apparatus of claim 4 wherein said oscillator device is connected to said
2 first transducer for driving said membrane at said reference resonant frequency and said
3 frequency detection device is connected to said second transducer for determining the
4 change in said reference frequency.

1 6. The apparatus of claim 1 wherein said sensor further includes a plurality of
2 walls peripheral to said membrane, said plurality of walls cooperating to define a cavity
3 having said membrane as a bottom portion thereof.

1 7. The apparatus of claim 1 wherein the deposition of the substance on the
2 membrane causes a decrease in the reference resonant frequency, thereby indicating an
3 increase in the mass of the substance disposed on the membrane.

1 8. The apparatus of claim 1, wherein said substance is present in a volume of a
2 volatile solution which is deposited on said membrane, the mass of the substance being
3 measured after the solution evaporates, leaving the substance on the membrane.

1 9. The apparatus of claim 8, further including a concentration determining
2 device for comparing the mass of the substance to the volume of the solution to determine
3 the concentration of the substance within the volume of the solution.

1 10. The apparatus of claim 9 wherein the substance is a non-volatile residue.

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1 11. The apparatus of claim 1 further including a display device connected to said
2 microprocessor for displaying the mass of said substance.

1 12. The apparatus of claim 1, further including a heating device for heating said
2 substance after it has been deposited on said membrane to evaporate moisture from said
3 substance, said frequency detection device determining the change in the reference resonant
4 frequency after the moisture is evaporated from said substance.

1 13. The apparatus of claim 12 further including a moisture content determining
2 device;
3 wherein the mass determining device determines the mass of the
4 substance after the substance is heated and the moisture content determining device
5 determines the moisture content of the substance by comparing the mass of the substance
6 before it is heated to the mass of the substance after it is heated.

1 14. The apparatus of claim 12 further including a boiling point determining
2 device;
3 wherein the heating device heats the substance with a temperature which is
4 increasing at a constant rate which causes the reference resonant frequency to increase at a
5 first rate as the mass of the substance decreases;
6 the frequency detection device monitors the rate of change of the reference
7 resonant frequency as the substance is heated; and

1 15. The apparatus of claim 1 wherein an increase in the reference resonant
2 frequency indicates a decrease in the mass of the substance on the membrane.

1 16. The apparatus of claim 1 including a plurality of sensors configured in an
2 array, each of the sensors being connected between said oscillator device and said frequency
3 detection device.

1 17. A method for measuring the mass of a substance, the method comprising the
2 steps of:

3 driving a membrane of a sensor at a reference resonant frequency;
4 depositing the substance onto the membrane of the sensor;
5 measuring a shifted frequency within the membrane;
6 detecting a change of the shifted frequency from the reference resonant
7 frequency; and
8 determining the mass of the substance based on the change of the shifted
9 frequency from the reference resonant frequency.

1 18. The method of claim 17 wherein said depositing step comprises placing a
2 volume of volatile solution containing the substance on the membrane and allowing the
3 solution to evaporate, the substance thereby remaining on the membrane.

1 19. The method of claim 18, further comprising the step of comparing the mass
2 of the substance to the volume of the solution to obtain the concentration of the substance
3 within the solution.

1 20. The method of claim 17 further comprising the steps of:
2 heating the substance after the mass of the substance is determined to
3 evaporate any moisture in the substance;
4 measuring the post-heating frequency in the membrane after the heating

5 step;

6 detecting a change of the post-heating frequency from the shifted

7 frequency; and

8 determining the mass of the substance after the heating step based on

9 the change of the post heating frequency from the shifted frequency.

1 21. The method of claim 20 further comprising the step of determining the
2 moisture content of the substance before the heating step takes place, based on the
3 difference in the mass of the substance before the heating step and the mass of the
4 substance after the heating step.

1 22. The method of claim 17 wherein said depositing step comprises placing the
2 sensor in a fluid environment and allowing a volatile solution contained in the fluid
3 environment to collect on the membrane.

PENTEX PROCESS

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4 23. An apparatus for measuring a change in the mass of a substance within the
5 subnanogram range.

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